1. A functionalized polymer for binding a solute or a suite of solutes dissolved in a solution comprising:

a polymeric backbone; and

one or more functional groups covalently linked to the polymeric backbone, the one or more functional groups selected to bind to the solute or a suite of solutes, the one or more functional groups selected from the group consisting of a monol derivative, a diol derivative, a triol derivative, a tetraol derivative, a glucarone derivative, a thiol derivative, a dithiol derivative, an alpha-hydroxycarboxylic acid derivative, a tartrate derivative, a calixarene derivative, a polypeptide derivative, bisphosphonic acid derivatives, biscarboxylic acid derivatives and bisamide derivatives, bisester derivatives, a monoester derivative, a monoamide derivative, a mixed phosphonic acid/carboxylic acid derivative, an alkylpyridinium derivative, a cyclodextran derivative, an antibody, a Fab fragment of an antibody, a $F(ab)_2$ of an antibody, an antigen, a cavity of selected size that hosts the solute selectively, a cage-shaped host, guest-host groups, and affinity groups.

2. The functionalized polymer of claim 1, wherein the polymeric backbone is selected from the group consisting of polyvinylamine, polyallylamine, polyacrylamide, polyethylenimine, polyacrylic acid, polymethacrylic acid, polyvinylalcohol, polyvinylacetate, polypyrrol, and hyperbranched polymers.

3. The functionalized polymer of claim 1, wherein the diol derivative is tartrate.

4. The functionalized polymer of claim 3, wherein the tartrate is covalently linked to the polymeric backbone to from a cyclic tartrate imide.

5. The functionalized polymer of claim 3, wherein the tartrate is covalently linked to the polymeric backbone to form an open monoester, which can be converted to a carboxylic acid.

6. The functionalized polymer of claim 3, wherein the tartrate is covalently linked to the polymeric backbone to form a diamide attached to two different nitrogen atoms of the polymeric backbone.

7. The functionalized polymer of claim 1, wherein the diol derivative is glycidol.

8. The functionalized polymer of claim 1, wherein the functionalized polymer is crosslinked thereby rendering the functionalized polymer insoluble in water.

9. The functionalized polymer of claim 1, wherein the functionalized polymer is water-soluble.

10. The functionalized polymer of claim 9, wherein the functionalized polymer is purified to have polymer molecule sizes capable of being retained by a membrane with a molecular weight cutoff value of a first pre-selected level and essentially free of polymer molecule sizes capable of passing through a membrane with a molecular weight cutoff value of a second pre-selected level the second preselected level being smaller than the first pre-selected level.

11. The functionalized polymer of claim 10, wherein the functionalized polymer has a molecular weight in the range from about 1,000 to about 1,000,000.

12. The functionalized polymer of claim 10, wherein the functionalized polymer has a molecular weight in the range from about 10,000 to about 100,000.

13. The functionalized polymer of claim 1, wherein the functionalized polymer is represented by the formula X-R wherein "X" is a synthetic polymer selected from the group consisting of polyethylenimine, polyvinylamine, polyallylamine, polypropylamine polyacrylamide, polyethylenimine, polyacrylic acid, polymethacrylic acid, polyvinylalcohol, polyvinylacetate, polypyrrol, or hyperbranched polymers and "R" is a functional group selected from the group consisting of a monool derivative, a diol derivative, a tetraol derivative, a triol derivative, an alphahydroxycarboxylate derivative, a glucarone derivative, and a dithiol derivative.

14. The functionalized polymer of claim 13, wherein the polymer is water soluble.

15. The functionalized polymer of claim 14, wherein the functionalized polymer is purified to have polymer molecule sizes capable of being retained by a membrane with a molecular weight cutoff value of a first pre-selected level and essentially free of polymer molecule sizes capable of passing through a membrane with a molecular weight cutoff value of a second pre-selected level the second pre-selected level being smaller than the first pre-selected level.

16. The functionalized polymer of claim 14, wherein the functionalized polymer has a molecular weight in the range from about 1,000 to about 1,000,000.

17. The functionalized polymer of claim 14, wherein the functionalized polymer has a molecular weight in the range from about 10,000 to about 100,000.

18. The functionalized polymer of claim 13, wherein the solute or suite of solutes is selected from the group consisting of species of arsenic, barium, cadmium, chromium, mercury, lead, silver, selenium, actinides, lanthanides, copper, nickel, zinc, cobalt, boron, silicon, and antimony.

19. The functionalized polymer of claim 1, wherein the functionalized polymer is represented by the formula X-R, wherein "X" is a synthetic polymer selected from the group consisting of polyethylenimine, polyvinylamine, polyallylamine, polypropylamine polyacrylamide, polyethylenimine, polyacrylic acid, polymethacrylic acid, polyvinylalcohol, polyvinylacetate, polypyrrol, or hyperbranched polymers and "R" is a functional group selected from the group consisting of a thiol derivative, a tartrate derivative, a calixarene derivative, a polypeptide derivative, bisphosphonic acid derivatives, biscarboxylic acid derivatives and bisamide derivatives, bisester derivatives, a monoester derivative, a monoamide derivative, a mixed phosphonic acid/carboxylic acid derivative, an alkylpyridinium derivative, a cyclodextran derivative, an antibody, a Fab fragment of an antibody, a $F(ab)_2$ of an antibody, an antigen, a cavity of selected size that hosts the solute selectively, a cage-shaped host, guest-host groups, and affinity groups.

20. The functionalized polymer of claim 19, wherein the polymer is water soluble.

21. The functionalized polymer of claim 20, wherein the functionalized polymer is purified to have polymer molecule sizes capable of being retained by a membrane with a molecular weight cutoff value of a first pre-selected level and essentially free of polymer molecule sizes capable of passing through a membrane with a molecular weight cutoff value of a second pre-selected level the second pre-selected level being smaller than the first pre-selected level.

22. The functionalized polymer of claim 20, wherein the functionalized polymer has a molecular weight in the range from about 1,000 to about 1,000,000.

23. The functionalized polymer of claim 20, wherein the functionalized polymer has a molecular weight in the range from about 10,000 to about 100,000.

24. The functionalized polymer of claim 19, wherein the solute or suite of solutes is selected from the group consisting of species of arsenic, barium, cadmium, chromium, mercury, lead, silver, selenium, actinides, lanthanides, copper, nickel, zinc, cobalt, boron, silicon, and antimony.

25. The functionalized polymer of claim 1, wherein the solute or suite of solutes is selected from the group consisting of species of arsenic, barium, cadmium, chromium, mercury, lead, silver, selenium, actinides, lanthanides, copper, nickel, zinc, cobalt, boron, silicon, iodine, and antimony.

26. A functionalized synthetic polymer for binding a solute or a suite of solutes dissolved in a solution comprising:

a water-soluble backbone polymer selected from the group consisting of polyethylenimine, polyvinylamine, polyallylamine, polypropylamine polyacrylamide, polyethylenimine, polyacrylic acid, polymethacrylic acid, polyvinylalcohol, , polyvinylacetate, polypyrrol, or hyperbranched polymers; and

one or more functional groups covalently linked to the polymeric backbone, the one or more functional groups selected to bind to the solute or a suite of solutes, the one or more functional groups selected from the group consisting of a monol derivative, a diol derivative, a triol derivative, a tetraol derivative, a glucarone derivative, a thiol derivative, a dithiol derivative, an alpha-hydroxycarboxylic acid deravitive, a tartrate derivative, a calixarene derivative, a polypeptide derivative, bisphosphonic acid derivatives, biscarboxylic acid derivatives and bisamide derivatives, bisester derivatives, a monoester derivative, a monoamide derivative, a mixed phosphonic acid/carboxylic acid derivative, an alkylpyridinium derivative, a cyclodextran derivative, an antibody, a Fab fragment of an antibody, a $F(ab)_2$ of an antibody, an antigen, a cavity of selected size that hosts the solute selectively, a cage-shaped host, guest-host groups, and affinity groups, the functionalized polymer being purified to have polymer molecule sizes capable of being retained by a membrane with a molecular weight cutoff value of a first pre-selected level and essentially free of polymer molecule sizes capable of passing through a membrane with a molecular weight cutoff value of a second pre-selected level the second pre-selected level being smaller than the first pre-selected level.

27. The functionalized polymer of claim 26, wherein the diol derivative is tartrate.

28. The functionalized polymer of claim 27, wherein the tartrate is covalently linked to the polymeric backbone to from a cyclic tartrate imide.

29. The functionalized polymer of claim 27, wherein the tartrate is covalently linked to the polymeric backbone to form an open monoester.

30. The functionalized polymer of claim 27, wherein the tartrate is covalently linked to the polymeric backbone to form a diamide attached to two different nitrogen atoms of the polymeric backbone.

31. The functionalized polymer of claim 26, wherein the functionalized polymer has a molecular weight in the range from about 1,000 to about 1,000,000.

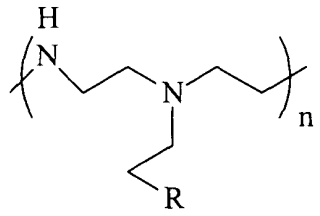
32. The functionalized polymer of claim 26, wherein the functionalized polymer has a molecular weight in the range from about 10,000 to about 100,000.

33. The functionalized polymer of claim 32, wherein the solute or suite of solutes is selected from the group consisting of species of arsenic, barium, cadmium, chromium, mercury, lead, silver, selenium, actinides, lanthanides, copper, cobalt, nickel, zinc, boron, silicon, iodine, and antimony.

34. The functionalized polymer of claim 26, wherein the solute or suite of solutes is selected from the group consisting of arsenic, barium, cadmium, chromium, mercury, lead, silver, selenium, actinides, lanthanides, copper, nickel, zinc, cobalt, boron, silicon, iodine, and antimony.

35. The functionalized synthetic polymer of claim 1, wherein the functionalized polymer is represented by the formula X-R wherein "X" is a polymer selected from the group consisting of polyethylenimine, polyvinylamine, polyallylamine, polypropylamine polyacrylamide, polyethylenimine, polyacrylic acid, polymethacrylic acid, polyvinylalcohol, , polyvinylacetate, polypyrrol, or hyperbranched polymer and "R" is a functional group selected from the group consisting of a monol derivative, a diol derivative, a triol derivative, a tetraol derivative, a glucarone derivative, a thiol derivative, a dithiol derivative, an alpha-hydroxycarboxylic acid deravitive, a tartrate derivative, a calixarene derivative, a polypeptide derivative, bisphosphonic acid derivatives, biscarboxylic acid derivatives and bisamide derivatives, bisester derivatives, a monoester derivative, a monoamide derivative, a mixed phosphonic acid/carboxylic acid derivative, an alkylpyridinium derivative, a cyclodextran derivative, an antibody, a Fab fragment of an antibody, a $F(ab)_2$ of an antibody, an antigen, a cavity of selected size that hosts the solute selectively, a cage-shaped host, guest-host groups, and affinity groups.

36. A functionalized polymer for binding a solute or a suite of solutes dissolved in a solution, the functionalized polymer comprising a molecule of the formula:



wherein n is an integer between about 12 and about 12,000 and R is NH_2 except at one or more positions within the polymer where R is a functional group independently selected from the group consisting of a monol derivative, a diol derivative, a triol derivative, a tetraol derivative, a glucarone derivative, a thiol derivative, a dithiol derivative, an alpha-hydroxycarboxylic acid deravitive, a tartrate derivative, a calixarene derivative, a polypeptide derivative, bisphosphonic acid derivatives, biscarboxylic acid derivatives and bisamide derivatives, bisester derivatives, a monoester derivative, a monoamide derivative, a mixed phosphonic acid/carboxylic acid derivative, an alkylpyridinium derivative, a cyclodextran derivative, an antibody, a Fab fragment of an antibody, a $F(ab)_2$ of an antibody, an antigen, a cavity of selected size that hosts the solute selectively, a cage-shaped host, guest-host groups, and affinity groups.

37. The functionalized polymer of claim 36, wherein the functionalized polymer is crosslinked thereby rendering the functionalized polymer insoluble in water.

38. The functionalized polymer of claim 36, wherein the functionalized polymer is water-soluble.

39. The functionalized polymer of claim 38, wherein the functionalized polymer is purified to have polymer molecule sizes capable of being retained by a membrane with a molecular weight cutoff value of a first pre-selected level and essentially free of polymer molecule sizes capable of

passing through a membrane with a molecular weight cutoff value of a second pre-selected level the second pre-selected level being smaller than the first pre-selected level.

40. The functionalized polymer of claim 39, wherein the functionalized polymer has a molecular weight in the range from about 1,000 to about 1,000,000.

41. The functionalized polymer of claim 39, wherein the functionalized polymer has a molecular weight in the range from about 10,000 to about 100,000.

42. The functionalized polymer of claim 39, wherein the solute or suite of solutes is selected from the group consisting of arsenic, barium, cadmium, chromium, mercury, lead, silver, selenium, actinides, lanthanides, copper, nickel, zinc, cobalt, boron, silicon, iodine, and antimony.

43. The functionalized polymer of claim 36, wherein the solute or suite of solutes is selected from the group consisting of arsenic, barium, cadmium, chromium, mercury, lead, silver, selenium, actinides, lanthanides, copper, nickel, zinc, cobalt, boron, silicon, iodine, and antimony.